



Understanding Superfund Risk Assessment

Office of Emergency and Remedial Response
Hazardous Site Evaluation Division (OS-230)

Superfund is the nation's program to clean up uncontrolled hazardous waste sites. Superfund's first concern is to take action whenever an immediate threat is discovered. Second, sites that pose the greatest potential risk to human health and the environment are placed on a National Priorities List (NPL) for long-term cleanup of contamination. Superfund sites are located in every state and potentially affect more than 41 million people who live within four miles of an NPL Superfund site.

Superfund works to reduce risk:

- Superfund has completed actions to reduce immediate threats at 1,760 NPL and non-NPL sites.
- At the 507 NPL sites where actions have been completed, the potential risks posed by exposure to hazardous waste have been reduced for 23.5 million people who live in a four-mile radius.
- A population equivalent to that of Atlanta, Georgia (450,000), has been provided with a safe alternative water supply.
- A population equivalent to a near-capacity crowd at Boston's Fenway Park (30,000) has been relocated from sites posing immediate risks.

People who live near a Superfund site want to know how it could affect their health. This brochure explains how the U.S. Environmental Protection Agency (EPA) examines the potential risks to human health near Superfund sites. Its purpose is to help citizens understand the risk assessment process.

WHAT IS RISK ASSESSMENT?

Human health risk is the likelihood that people living, working, or playing at or near a Superfund site

could experience health problems as a result of their contact with, or "exposure" to, chemicals from the site. The type of health problems an individual might experience depends on the chemical, how much of the chemical a person is exposed to, and how long the exposure lasts. Some chemicals are harmful in small amounts and other chemicals are not harmful even in very large amounts.

To evaluate the potential human health risks at a Superfund site, EPA uses a procedure known as "risk assessment." (See Highlight 1.) Risk assessment is the scientific estimation of the probability of harm from exposure to the chemicals found at a site. It involves identifying what chemicals are at a site, estimating how and to what extent people might be exposed to these chemicals, and assessing the health effects associated with the chemicals.

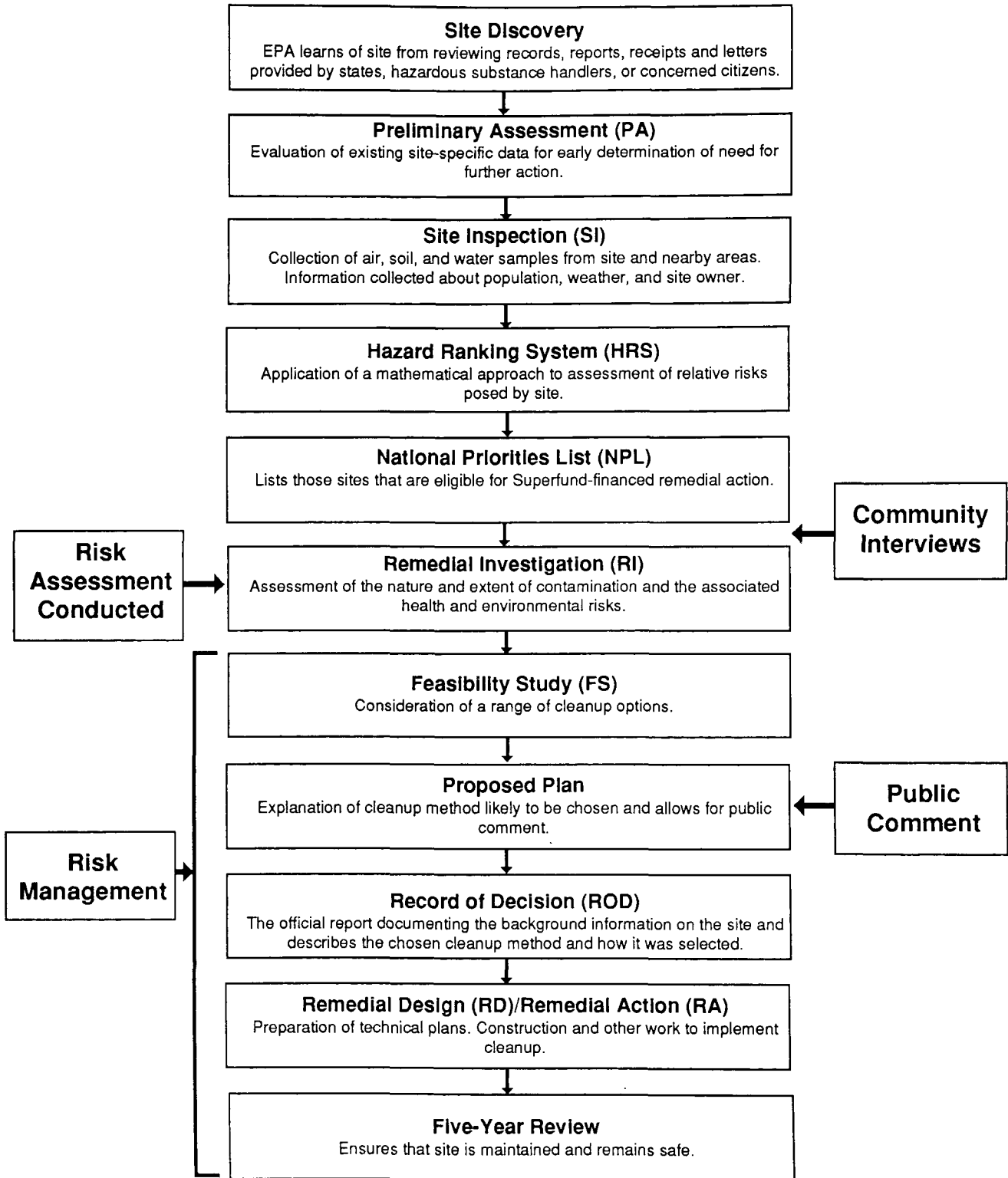
A Superfund risk assessment estimates the "baseline risk." This is the potential risk of health problems occurring *if no cleanup action is taken at a site*. The risk estimates are potential risks or predictions of risk. This is because the risk estimates are based on mathematical models that make assumptions about how people use the site and how they might be exposed to chemicals at the site. EPA collects samples to identify the chemicals present at a site. The location of the chemicals and the amounts present at the site are also determined. Except in rare cases, EPA does not take samples from humans to determine their exposure to the chemicals. EPA predicts human exposure by using models and standardized assumptions about how people use the site and how chemicals interact with the human body.

This differs from risk estimates like the chances of being injured in an automobile accident. Experts can count the number of automobile accidents that



HIGHLIGHT 1

The Superfund Process*



* At any point in the process, EPA can take immediate action to respond to immediate risks.

occurred last year to measure the actual risks of driving a car. There is no similar set of statistics for risks at Superfund sites, which is why EPA must make predictions of risk based on models and assumptions.

Because of the uncertainties in using the models to predict risk at Superfund sites, EPA uses assumptions in its models that tend to increase the two factors that compose risk. These two factors are exposure to a chemical and the harmfulness, or "toxicity," of a chemical. By increasing the two factors that make up the risk, the risk may be overestimated. EPA's responsibility is the protection of human health and the environment. EPA makes its decisions to protect people based on estimates of risk. It is important that EPA not underestimate risk to help ensure the protectiveness of those decisions.

For the most part, when the term "risk" is used at a Superfund site, it is the baseline risk—the potential risk of health problems if no cleanup action takes place. Because EPA uses assumptions that tend to overestimate the predictions of risk, the actual number and seriousness of health problems experienced by the community will generally be lower than predicted by EPA.

RISK MANAGEMENT

HIGHLIGHT 2

Risk Management Questions

- Should cleanup be undertaken?
- What should the cleanup levels be?
- What cleanup method should be used?

The process of using the results of a risk assessment to make decisions at a Superfund site is known as "risk management." The results of the baseline risk assessment help EPA to decide whether to undertake cleanup at the site. EPA uses risk assessment to help determine what the level of cleanup should be when legal environmental standards are not available. Risk assessment is also used to predict the potential health risks, if any, of different types of cleanup methods. (See Highlight 2.)

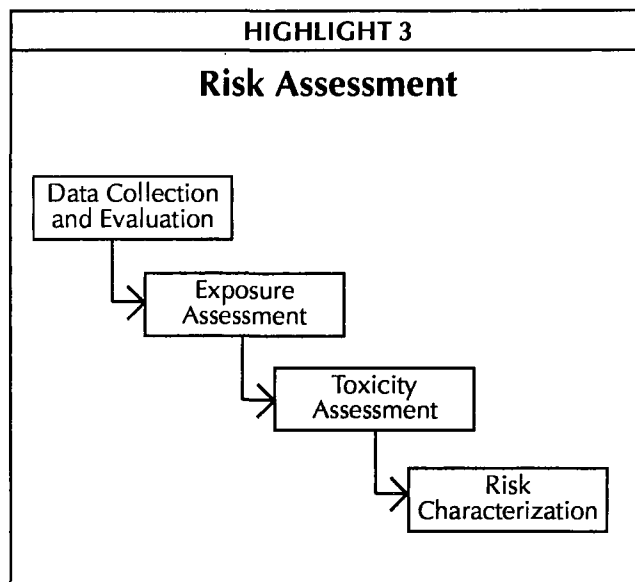
THE FOUR STEPS OF RISK ASSESSMENT

EPA uses a four-step process for risk assessment at Superfund sites. (See Highlight 3.) It is based on recommendations made by the National Research

Council in 1983. The National Research Council is an independent advisor to the government on scientific questions.

STEP 1. DATA COLLECTION AND EVALUATION

In the first step, samples of the air, water, soil, plants, and animals are taken from locations in and around the site. These samples are analyzed to determine what chemicals are present and their quantity and location.



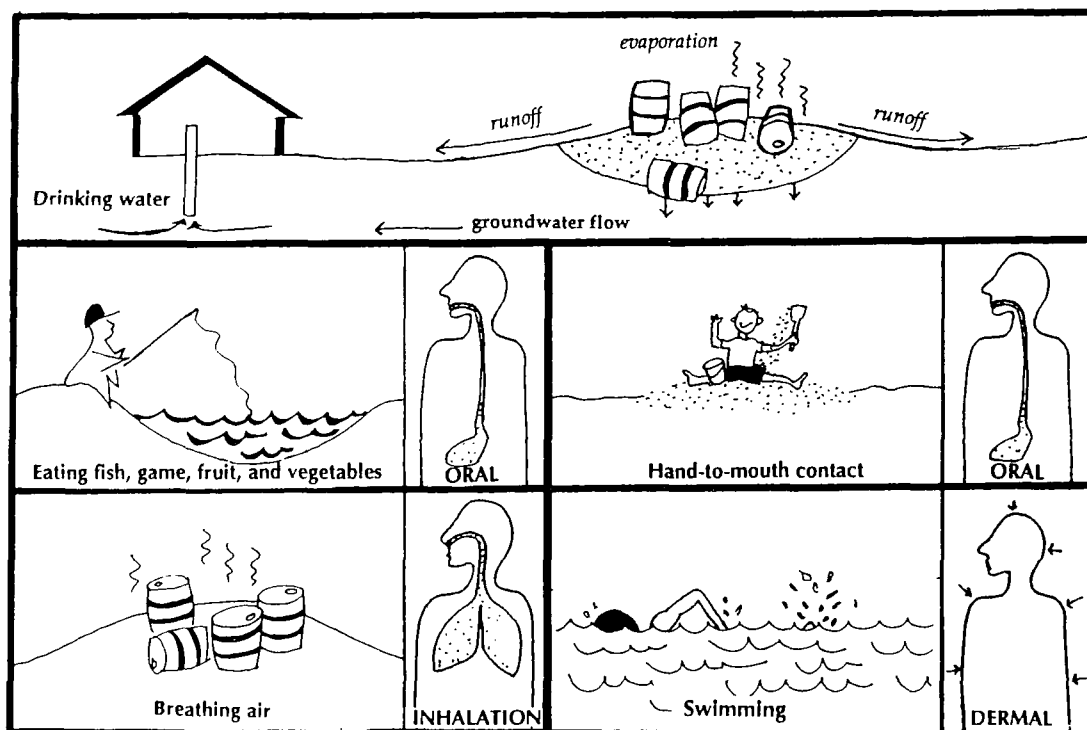
STEP 2. EXPOSURE ASSESSMENT

In this step, risk assessors estimate the exposure that members of the community might have to the chemicals identified in STEP 1. People may come in contact with chemicals through the air, water, soil, food, or other "pathways." For each pathway, risk assessors estimate the amount of a chemical that could reach a person's lungs, digestive system, or skin. Some chemicals are harmful in small amounts and other chemicals are not harmful even in very large amounts. The important consideration is people's exposure to the chemicals.

In order to estimate through models and standard assumptions how much of the chemicals people are likely to be exposed to, risk assessors look at how people use the site or areas near the site. (See Highlight 4.) Risk assessors ask questions such as: Do people live or work on or near the site? Do children play on or near the site? Do people drink or shower in water contaminated with chemicals from the site? Do people eat fish from or swim in streams or lakes contaminated by chemicals from the site?

HIGHLIGHT 4

Exposure Pathways



Does No Exposure Mean No Risk?

In conducting a risk assessment, EPA may determine that although there are hazardous chemicals on a site, there is little chance that people will come in contact with the chemicals. For example, if there are no lakes, rivers, or groundwater at the site, and the chemicals cannot evaporate, or are buried deep in the ground, then there may be no opportunity for the chemicals to move from the site to areas where people would come in contact with them. If there is no possibility of exposure to the chemicals, and there is no reason to believe that there will be in the future, then the chemicals pose no risk.

What about High Exposure Groups?

As a matter of policy, EPA chooses to use estimates of exposure for individuals in high exposure groups as a part of a risk assessment done at a Superfund site. Take, for example, a Superfund site located near a school playing field. Both children and adults can be found on the field. However, a typical child in the neighborhood uses the field more often and in different ways than an adult does. In this example, children are considered to be the high exposure group and EPA would use the exposure estimates for children in the risk assessment calculations.

The high exposure group is not the absolute worst case of exposure. EPA recognizes that not everyone in a community will be part of the high exposure group. Many people will have less exposure than the high exposure group. EPA uses the highest exposure they reasonably expect might happen. This is known as the "Reasonable Maximum Exposure" or "RME". This is a term you might hear when the risk assessment for your site is being discussed.

What About the Future?

EPA also considers the potential for future exposures in this step. A site with little human activity in the present might be expected to be used for homes and schools in the future. If this is the case, EPA would also estimate exposure based on that future use.

STEP 3. TOXICITY ASSESSMENT

To determine if the chemicals found at a site might cause health problems, risk assessors look at the results of toxicity studies. Toxicity studies, usually performed on laboratory animals, examine the health effects of exposure to measured amounts of chemicals. There are few human studies on the effects of chemicals on human health. Instead, EPA must base its predictions primarily on experiments that scientists have done using test animals.

The type of health problem varies depending on the chemicals and the amount of exposure, or dose. Health problems can include rashes, trouble with breathing, damage to vital organs, birth defects, cancer, or even death. In general, scientists group these health problems into two types: cancer and all others (noncancer).

Carcinogens

Chemicals that cause cancer are called carcinogens. For carcinogens, toxicity studies show that the number of cases of cancer usually increases as the dose increases. The reverse is also true. As the dose decreases, the occurrence of cancer decreases. Any amount of exposure to a carcinogen carries some risk of developing cancer. The rate of this increase or decrease measures the strength of a carcinogen. The measure of a carcinogen's strength is called a "slope factor."

To determine the toxicity of a carcinogen, scientists must rely on animal studies and models. Their models have built-in assumptions that tend to overestimate the harmfulness of the carcinogen.

Noncarcinogens

Chemicals that cause health effects other than cancer are known as noncarcinogens. For example, lead can cause anemia and retarded intelligence. Children are especially affected. Like carcinogens, as exposure to a noncarcinogen increases, the harmfulness of the health effect usually increases too.

Scientists believe that there is a certain dose of a noncarcinogen that the human body can tolerate without showing signs of illness. For example, studies seem to show that too much of the chemical nitrate can cause blood disorders in children. Using toxicity studies and models, EPA has estimated that an individual could eat or drink a specific amount of nitrate each day for 70 years without experiencing a blood disorder. This amount takes into account that children are especially affected. This amount is known as the "Reference Dose" for nitrate. Since the exact amount of a chemical people can tolerate depends on the chemical, Reference Doses are different for different chemicals.

The concept of a Reference Dose is an important difference between noncarcinogens and carcinogens. Toxicity studies for carcinogens seem to show that exposure to any amount of a carcinogen carries some risk of developing cancer.

The results of animal studies cannot be applied directly to humans. To take into account this uncertainty, scientists translate the results of animal

studies using theoretical models that take into account human sensitivity and special populations, like children. The models have built-in assumptions that tend to overestimate the harmfulness of the chemicals.

STEP 4. RISK CHARACTERIZATION

In this step, the work and results of the three previous steps are combined, evaluated, and summarized. Here, the risk assessor determines the kinds of risks and whether the risks are great enough to cause health problems for people at or near a site.

EPA calculates the risks from carcinogens and noncarcinogens differently. Risk assessors present their estimate of carcinogenic risk as a probability (or chance) that a person would develop cancer over his or her lifetime due to exposure to a particular carcinogen, or carcinogens, at a site. As discussed in STEP 2, risk assessors use the exposure levels of the highest exposure groups when calculating the probability.

For example, EPA may estimate that the cancer risk from a site is "one-in-a-million." This means that if one million people from the high exposure group were exposed to chemicals at the site, EPA estimates that, at the most, one case of cancer could occur as a result. Most members of a community are not a part of this high exposure group. An individual who experiences less exposure than those in the high exposure group would have even less of a chance of developing cancer.

For a noncarcinogen, risk assessors make a comparison between the exposure predicted in Step 2 and the Reference Dose for the noncarcinogen. The comparison is expressed as a number, usually close to the number 1.

RISK MANAGEMENT

The process of using the results of a risk assessment to make decisions at a Superfund site is known as "risk management." The results of the baseline risk assessment help EPA to decide whether to undertake cleanup at the site. For carcinogens, if the baseline risk assessment indicates that the risk is greater than 1-in-10,000, or if Federal or State environmental standards are exceeded, site managers will generally begin cleanup activities. If the results of the baseline risk assessment indicate that the risk is between 1-in-10,000 and 1-in-1,000,000, cleanup action will generally not be taken by EPA, unless Federal or State environmental standards are exceeded.

For a noncarcinogen, if the comparison shows the exposure predicted in STEP 2 is greater than the

Reference Dose for the noncarcinogen, cleanup action will usually take place. When this comparison number exceeds "1", EPA will generally take cleanup action. For example, if this comparison between the Reference Dose for a noncarcinogen and the predicted exposure in STEP 2 to that noncarcinogen is the number "0.5", cleanup activities would generally not be undertaken. On the other hand, if this comparison resulted in the number "2", cleanup activities would most likely begin.

What about Multiple Chemicals?

Scientists do not yet know how most chemicals interact with one another. One theory is that some chemicals may cancel the effects of another, resulting in less risk. Another theory is that chemicals may interact to increase harmful health effects, resulting in even greater risk. Because of this uncertainty, EPA recommends that the risks from more than one chemical be added together. This means that the risk number for carcinogens at a site reflects the risks from all of the carcinogens at the site and that the risk number for noncarcinogens represents the risk from all of the noncarcinogens found at a site.

UNCERTAINTY

Risk assessment is not an exact science. While EPA tries to estimate risk as accurately as possible, there are many sources of uncertainty in a risk assessment. Exposure is predicted based on models and assumptions about how people living near a Superfund site might come into contact with the chemicals. How well the results of animal laboratory studies can predict the effects of chemicals on humans is also the subject of controversy among scientists.

EPA must make a choice, or a policy decision, as to how it will deal with these uncertainties. In general, EPA uses assumptions and models that may overestimate risk instead of using assumptions and models that might underestimate the risk in order to make sure its decisions protect the health of the people nearby. As science comes to better understand how chemicals affect human health, EPA will be better able to estimate risk.

HOW CAN I GET MORE INVOLVED?

A Community Relations Coordinator (CRC) is assigned to each Superfund site by EPA. The CRC is an excellent source of information about activities at a site. Telephone numbers for contacting the CRC for a particular site are given at the end of this section.

Citizens living or working near a Superfund site can contribute valuable information for the development of the baseline risk assessment, particularly if they get involved early in the assessment process. For example, community members can provide information about pathways of exposure, historical activities, and future use of the site during community interviews.

EPA's Technical Assistance Grant (TAG) Program is available to assist with the review of technical information about the site and promote community involvement in the decision-making process at Superfund sites. The TAG Program provides an initial grant of up to \$50,000 to community groups near sites on, or proposed for listing on, the National Priorities List. The TAG recipient group is required to contribute 20% in matching funds toward the total costs of the program. The matching funds requirement may be met with cash or through in-kind administrative services. The community may use TAG funds to hire a technical advisor to help them understand information that already exists about their site or information developed during the cleanup process. This information may include conditions at the site, the nature of the waste involved, and the kind of technology available for performing the necessary cleanup. A TAG award may be renewed to facilitate community involvement at all stages of cleanup. Details about the TAG Program are provided in the EPA booklet entitled *Superfund Technical Assistance Grants*, available free of charge from EPA's Center for Environmental Research Information. The telephone number is (513) 569-7562. The order number for the booklet is EPA/540/8-90/013.

To find out more about your site, contact the Community Relations Coordinator in the EPA Regional Office for your State at the number listed below.

Region 1: Boston, MA (617) 565-3425
(States: CT, ME, MA, NH, RI, VT)

Region 2: New York, NY (212) 264-7054
(States: NJ, NY, PR, VI)

Region 3: Philadelphia, PA (215) 597-9905
(States: DE, DC, MD, PA, WV, VA)

Region 4: Atlanta, GA (404) 347-2643
(States: AL, FL, GA, KY, MS, NC, SC, TN)

Region 5: Chicago, IL (312) 886-6685
(States: IL, IN, MI, MN, OH, WI)

Region 6: Dallas, TX (214) 655-2240
(States: AR, LA, NM, OK, TX)

Region 7: Kansas City, KS (913) 551-7003
(States: IA, KS, MO, NE)

Region 8: Denver, CO (303) 294-1144
(States: CO, MT, ND, SD, UT, WY)

Region 9: San Francisco, CA (415) 744-2178
(States: AZ, CA, HI, NV)

Region 10: Seattle, WA (206) 553-6901
(States: AK, ID, WA, OR)

FOR FURTHER READING

EPA has prepared Fact Sheets about the Superfund process. You may request copies from the CRC for your site. The topics and EPA publication numbers are listed below.

An Overview 9230.0-05FSH
Identifying Sites 9230.0-05FSK
Exposure Pathways 9230.0-05FSB
The Removal Program 9230.0-05FSG
The Remedial Program 9230.0-05FSM
Community Interviews 9230.0-05FSI
Public Involvement 9230.0-05FSJ
Arsenic 9230.0-05FSA
Benzene 9230.0-05FSD
Trichloroethylene 9230.0-05FSC
PCBs 9230.0-05FSF
Information Repositories 9836.00-02FS

The following publications are available for a fee from the National Technical Information Service (NTIS). The telephone number is 1-800-553-NTIS.

U.S. Environmental Protection Agency. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, (Part A)*. December 1989. NTIS order number PB 90-155581.

U.S. Environmental Protection Agency. *Risk Assessment Guidance for Superfund, Volume II,*

Environmental Evaluation Manual. March 1989. NTIS order number PB 90-155599.

United States Council on Environmental Quality, Executive Office of the President. *Risk Analysis: A Guide to Principles and Methods for Analyzing Health and Environmental Risks*. 1989. NTIS order number PB 89-137772.

U.S. Environmental Protection Agency. *Hazardous Substances in Our Environment: A Citizen's Guide to Understanding Health Risks and Reducing Exposure*. September 1990. NTIS order number PB 91-131987. This publication is also available free of charge from EPA's Public Information Center. Phone (202) 260-2080. EPA document number EPA/230/9-90/081.

U.S. Environmental Protection Agency. *The Superfund Program: Ten Years of Progress*. June 1991. NTIS order number PB 91-921286.

Publications on related topics are available from the organizations listed below.

Bureau of Occupational Health, New York State Health Department. *Toxic Substances: How Toxic is Toxic?* (pamphlet). Free of charge. (518) 458-6392.

Institute for Environmental Studies. *A Matter of Chance, A Matter of Choice* (magazine). Free of charge. (608) 263-5599.

Institute for Environmental Toxicology, Michigan State University. *Toxicology for the Citizen* (booklet). First copy free of charge, additional copies \$1.00 each. (517) 353-6469.

For technical details and a review of current research on a particular chemical, you may wish to refer to the Agency for Toxic Substances and Disease Registry's Toxicological Profile for that chemical. Information on ordering profiles is available by calling ATSDR's Toxicology Information Service at (404) 639-6000 and requesting a "Tox Profile Information Sheet." The information service is accessible 24 hours per day by touchtone phone.